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SUBJECT: Proposal for Vehicle Image Recognition

92-29-1

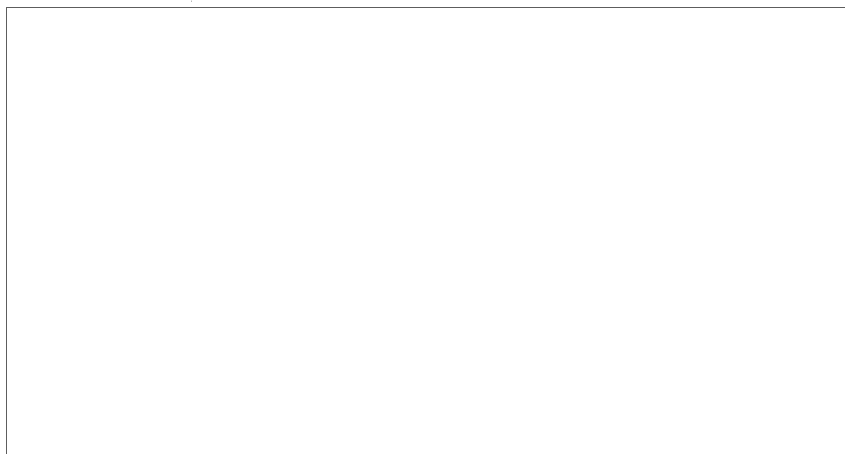
Henry:

Task V  
p. 202 B

Attached to this letter is the detailed description of our proposal to begin work on the problem of vehicle image recognition. In this work which is now being quoted, we propose to:

1. Carry out an investigation of the basic concepts of analysis of an optical image into the lowest possible number of elements required to accomplish identification on a digital basis.
2. Apply digital techniques to the development of circuits suitable for the signal processing and comparison with a memory.
3. Carry this program through a demonstration, under controlled conditions, of feasibility of the most promising techniques investigated. Background compensation will not be included.
4. Prepare a final technical report covering work done, results achieved, and information gained.

There is to be no equipment delivered under this task. Further, it is emphasized that this work is in the nature of a feasibility effort and as such, we cannot assure you of success. Our estimated costs are as follows:



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TOTAL Cost plus Fixed Fee \$ 71,089.80

We estimate that the program proposed can be completed in approximately twelve (12) months.

In the event that a contract is let for the development and fabrication of a system covered by this proposal, it is expressly understood that any and all inventions contained in this proposal shall not be considered a "subject invention" as defined by ASPR.



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Enclosure

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## PROPOSAL AND SPECIFICATIONS

In accordance with ASPR Sec. III, Rev. 17, Para. 3-109 dated 7 Sept. 1956  
"This data furnished in response to RFP No. \_\_\_\_\_, shall not be disclosed outside the Government or be duplicated, used or disclosed in whole or in part for any purpose other than to evaluate the proposal, that if a contract is awarded to this offeror as a result of or in connection with the submission of such data, this legend shall be of no force or effect; and the Government shall have the right to use the data for any purpose except as otherwise provided in the contract. This restriction does not limit the Government's right to use information contained in such data if it is obtained from another source."

### VEHICLE IMAGE RECOGNITION

Prepared for

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PREPARED BY

25X1

DATE

February 19, 1957

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VEHICLE IMAGE RECOGNITION

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I. Introduction

The [ ] proposes a program leading to the develop- 25X1  
ment of an equipment for vehicle image recognition for reconnaissance or surveillance  
purposes. It would be desirable to have a self contained device which could be

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This information would be stored in some form of memory to be transmitted  
out by radio when interrogated. The problems of storage of count and details  
of the radio channel for transmitting when required are not considered a part  
of this proposal. It is assumed that prior work in this field would be appli-  
cable.

II. Problem and Proposed Solution

Various techniques have been, in the past, considered for automatic vehicle  
identification such as acoustic means, seismic means, interruption or reflection of  
beams of light or infra red radiation, high resolution radar etc. The major  
problem has been to secure an adequately distinctive signal, characteristic of a  
particular vehicle type, in a form which can be used for reliable identification.

The signals produced by the sensing means have usually consisted of a time  
sequence of complex waveforms having characteristics of frequencies, amplitudes  
and durations which were to be recognized as unique for a particular vehicle type.  
The analysis of these signal characteristics and comparison with reference  
standards to determine the degree of correlation has been a complex and difficult  
procedure.

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Looking at the fundamental problem it is evident that an optical image of a vehicle contains much more detail than is required for recognition. A relatively crude silhouette is usually more than adequate for separating various vehicle types.

Accepting the principal limitation of an optical method, namely, that it requires illumination of the subject, a new approach to the problems of scanning and signal processing appears to be promising.

The present proposal is based upon an application of digital techniques to analyze an optical image, a reduction of the significant elements of that image to a manageable number of digital pieces of information, sufficient to represent a rough silhouette, and comparison of these with a digital memory which has in it an equivalent representation of the outline of the vehicle to be recognized. There are many problems to be solved before a determination can be made of how much resolution is actually required for reliable separation of the images of such vehicles as tanks, half tracks, trucks, troop carriers and jeeps, under the varying conditions that may exist. These problems would be a part of the studies here proposed.

Once the required degree of resolution has been determined, the minimum number of image elements to be separated by a scanner can be chosen and development of the scanner and its circuitry can proceed. The number of memory elements required for an equipment will of course depend on the number of image elements. Development of the memory elements themselves and the comparison circuits can be carried forward and the major problems solved without constructing the numerous duplicate elements that might be required in a complete equipment.

After development and test of the various required components, feasibility of the system can be demonstrated.

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III. Proposed Program

It is proposed that this program be carried on in phases. The ultimate goal is the design of a prototype equipment suitable for field tests. The present proposal however covers only the work up to and including a demonstration of feasibility of the techniques to achieve the desired recognition differential between vehicle types.

This program would be an investigation of the basic concepts of analysis of an optical image into the lowest possible number of elements required to accomplish identification, and of the use of digital techniques for the signal processing and comparison with a memory.

The detailed system outlined in the technical description which follows, while representative of our current thinking on the problem, may however, be subject to modification as the program progresses.

In a feasibility program such as this the degree of success can not be guaranteed.

Phase I. Study of resolution requirements and statistical properties of the system.

This phase would use paper outlines of vehicles and paper models of the proposed viewing elements to determine the fineness of resolution required for recognition. A logic process identical to that proposed can be applied manually to the observation made on the models, to prove the validity of the logic and to establish suitable statistical levels of acceptance for the various logic steps.

Phase II Circuit and Optics development

This phase would lead to the choice of appropriate circuits and techniques

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to perform the various logical operations in the recognition system. The choices will be made with the intention of developing the simplest possible circuits for the purpose. Suitable photoelectric pickups would be tested and choices made, with the immediate objective of equipping a feasibility sample. Work on this phase would proceed concurrently with the study of Phase I.

The development of circuits to compensate for background would not be included in this proposal. While essential for the operation of a full scale equipment, its action is independent of the basic scanning and logic of the proposed system. It is deemed more important to first demonstrate successful operation of the system in the presence of a uniform and constant background, and then develop automatic background correction circuits in a later phase.

#### Phase III Feasibility Equipment Development

To demonstrate the feasibility of the proposed system in the shortest time and with the least expenditure, a sample of the system would be built with a fewer number of image elements than would be required for the final equipment as determined in phase I. The feasibility can be adequately demonstrated on such a sample by placing appropriate restrictions on the prepared images which are presented to it. The use of fewer elements only affects the quantity of otherwise identical circuits in the scanner, programmer, and memory, and for this reason makes no sacrifice of generality in demonstrating electrical performance. This phase would follow the completion of phases I and II.

#### Summary of Program Objectives

We propose to:-

1. Carry out an investigation of the basic concepts of analysis of an optical image into the lowest possible number of elements required to accomplish identification on a digital basis.

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2. Apply digital techniques to the development of circuits suitable for the signal processing and comparison with a memory.
3. Carry this program through a demonstration, under controlled conditions, of feasibility of the most promising techniques investigated. Background compensation will not be included.
4. Keep the customer informed by means of informal monthly letter progress reports.
5. Prepare a final technical report covering work done, results achieved and information gained.

It is understood that no equipment is to be delivered under this task.

#### IV. Technical Description of Proposed System

It is proposed that equipment be developed that would recognize a given moving vehicle by producing with electro-optical means a numerical representation of the vehicle silhouette and correlating these numbers with those stored in a memory system. The concept of reducing the observed images to numerical information makes possible the use of digital computer techniques in memory and correlation. Since only a relatively small number of elemental areas appear to be necessary in the field of view to produce recognition, a digital approach offers advantages of simplicity, flexibility, dependability and size. In addition the use of the fewest possible number of elemental areas is very desirable. A study would be undertaken, using scale outlines of a wide variety of vehicles, to predetermine this minimum number of elements for satisfactory recognition capability on a theoretical basis.

The starting point for converting the image information to digital form is at the individual optical observation elements. Consider, in the optically focussed

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image of the field of view of the proposed complete recognition device, one elemental area. In the absence of moving objects in the field, a background pattern (roadside, fences, trees, sky, etc) is present, which produces a certain intensity of light at each elemental area. Assume each elemental area equipped with a photoelectric pickup device. If a circuit is provided on each pickup which will pass only variations in pickup output, the presence of a moving object over the elemental area can be distinguished from the background. It is practical to have such a circuit retain the information of a change in light level for a substantial length of time, while a vehicle is passing, yet ignore slow changes produced by the angle of the sun or changing conditions of overcast.

This recognition of departure from background value at an element would next be fed through a trigger circuit, so that the information becomes "yes-or-no", and thereafter all signals consist of the presence of voltage when a moving object is observed or the absence of this voltage when background is observed. Information in this form is referred to as "binary" or "on-off" or "one-zero".

Next, possibilities for handling the binary information will be considered. First some general attributes of the images of vehicles as seen in the whole field of view will be listed.

- a. Magnification will be constant. This means that the distance between the road and the proposed device is stipulated, so that images of the desired object are of standard size, within tolerances to be determined.
- b. The desired image may be located anywhere vertically in the field of view.
- c. The desired image may be moving horizontally over a wide range of speed.
- d. The image may move in either horizontal direction.

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A tank sitting in the field of view is shown in Fig. 1A. For discussion, consider the complete signal representing the tank silhouette to be plotted here in space relationship. The 0's represent original background without change and the 1's represent the areas changed by the presence of the tank.

It is immediately evident that the effect of vertical location can be removed by ignoring the vertical placement of ones and zero in each column of elements and using only the quantity of them. Doing this may be considered as equivalent to a distortion of the silhouette, if the numbers from each column are represented on a bar graph, as in Fig. 1B, because all re-entrant shapes are eliminated (for instance the wheels of a truck would become bumps on the top of the graph). However, this distortion is consistent, and is not expected to have a serious effect on the ability to distinguish between various vehicles.

If however the distortion caused by this simplification of the image characteristics is found to be intolerable more information can be extracted by recording the number of zeroes between the base line and each group of 1's in the silhouette. This would improve the significance of the column correlation. Fig. 1C shows the same data as Fig. 1B with the addition of this information.

Further refinement could identify the gun or other features by recording in more detail the spatial relationships of the 1's and 0's. Investigation of this distortion would be included in the initial study.

An important advantage of reading only the number of ones in each column is that scanning in the vertical direction is eliminated. The readings are essentially a parallel reduction of the vertical spatial data, and are available instantaneously on demand. The savings in circuitry and ease with which high-speed correlation of the moving image can be accomplished appear very promising.

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A possible horizontal scanning arrangement which is compatible with the remaining attributes of the image is diagrammed in Fig. 2. This shows a field of view in which a vehicle occupies three different positions which result from its movement from left to right. At each edge of the field are a pair of slots a-b, c-d. A photoelectric pickup observes the light from each of these slots. The passage of the leading edge of the image over these slot pairs signals the start of a scan and its direction, that is, the signal sequence a-b signifies an image starting at the left, and d-c one starting at the right. Other sequences such as b-a and c-d would be ignored.

After each of the two slot pairs is located a vertical column of pickup elements. Only one of these columns is used at a time, and that is the one on the side where the image first appears, as observed by the slot pairs. The relative number of zeroes and ones in the column changes continually as the image moves past it. At successive intervals, readings of the number of ones are taken from the column. To make recognition possible by comparing these numbers with numbers in a memory, the readings must be taken at definite horizontal locations on the image, independent of its speed.

This can be accomplished by triggering the readings as the leading edge of the image passes a series of slot pickups extending across the field of view. Readings corresponding to the arrival of the leading edge at three different positions are shown in Fig. 2 for illustrative purposes. The number of vertical elements and slots shown is not intended to be significant. Each slot would be made tall enough and so located as to cover the region in which the leading edge would be expected to occur. To obtain the best signal-to-noise ratio, the slots would not be extended over the entire height of the field. If still better image recognizing ability is needed in the slots, each slot could be divided into

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sections with individual pickups and trigger circuits. The appearance of the image in any section of a slot can then be used to actuate the circuits associated with that slot.

Fig. 3 shows a block diagram of the recognition equipment which consists of:

- (a) Edge recognition units (2)
- (b) Direction selector
- (c) Vertical reading units (2)
- (d) Horizontal scan programmer
- (e) Memory unit
- (f) Line correlator
- (g) Line register
- (h) Frame correlator

Some of these blocks have already been described. The diagram shows one possible arrangement which could provide for recognition of a desired image. Different arrangements may be feasible, and the one shown might become substantially altered during the progress of the work.

The memory unit contains, in permanent form, all the numbers corresponding to the image that is to be recognized. The numbers are available in a definite sequence under direction of the horizontal scan programmer.

The edge recognition units start the operating sequence and through the direction selector set the required direction of operation of the horizontal scan programmer. Once started by one of the edge recognition units, the direction selector locks and maintains the operation until a horizontal scan has been completed.

The direction selector connects the vertical reading from the appropriate column to the line correlator, and directs the horizontal scan programmer to run

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in the required sequence. As each slot signal comes into the horizontal scan programmer, it directs the memory to feed the successive numbers stored therein to the line correlator, where they are compared with the vertical reading present at that time. Successful line correlations, (above a predetermined level of correlation) are stored in the line register.

The number of line correlations that need to be made will depend on the size of the vehicle being recognized. After the memory has made the required number of line correlations, it will send a number to the frame correlator for comparison with the quantity of successful line correlations stored in the line register. A satisfactory correlation level here will constitute a recognition output to be recorded in the radio data transmitting equipment, along with a signal which indicates the direction in which the vehicle passed.

As soon as frame correlation is completed, the scan programmer will be reset. The system should be able to accept the arrival of a new image from the same direction immediately, without requiring that the previous image leave the field of view. This can be accomplished by making the slot pickup circuits produce a signal only when the light level changes away from the background level. It may also be desirable to require that the light remain at background level for a definite time before a new signal can be produced, so that signals will not be produced by the variations in light that accompany the motion of the image.

The system cannot be expected to handle images passing in both directions at the same time. However, it does not appear necessary to interlock the direction selector with the slot signals to enforce a clear field before reversing, because the probability of getting a recognition output under this condition is very small. As soon as a clear space between vehicles passing in the new direction starts across the field, correct operation will resume.

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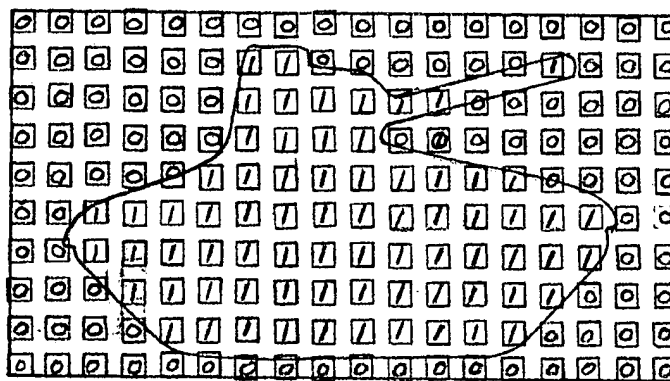


Fig. 1A

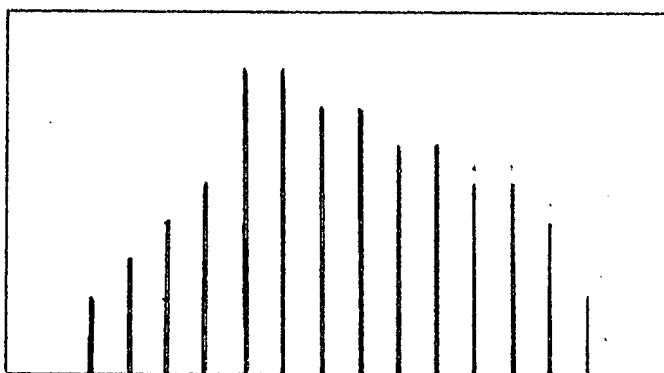


Fig. 1B

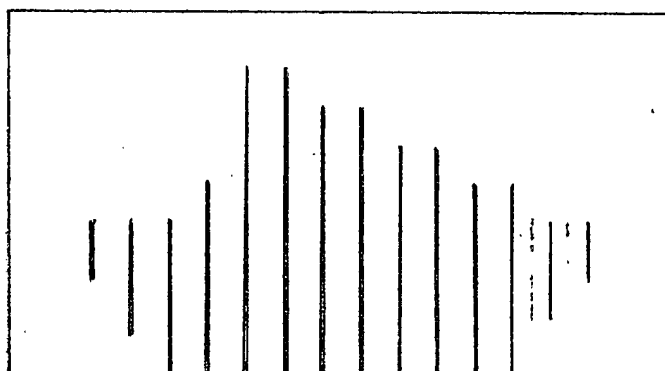


Fig. 1C

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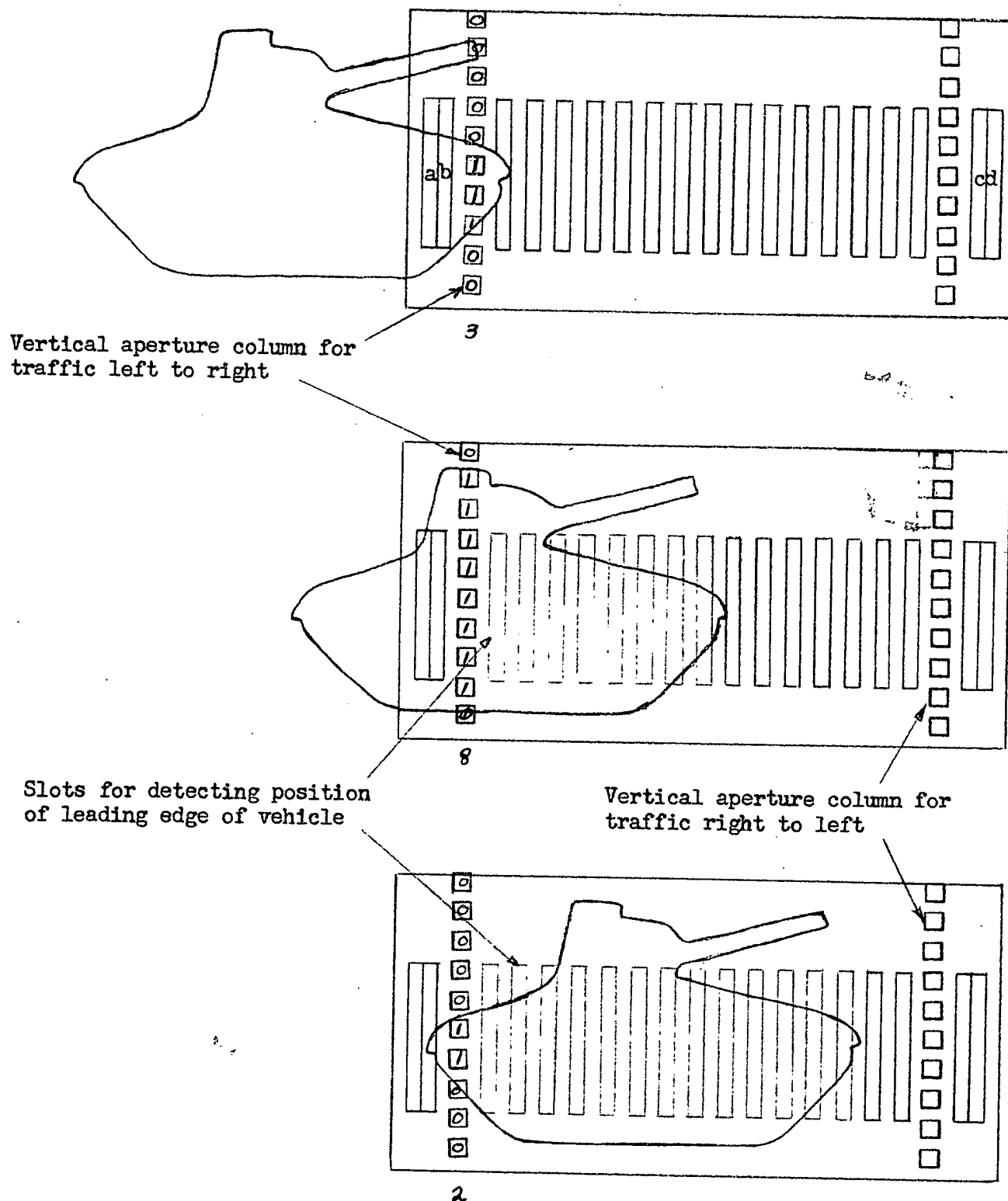
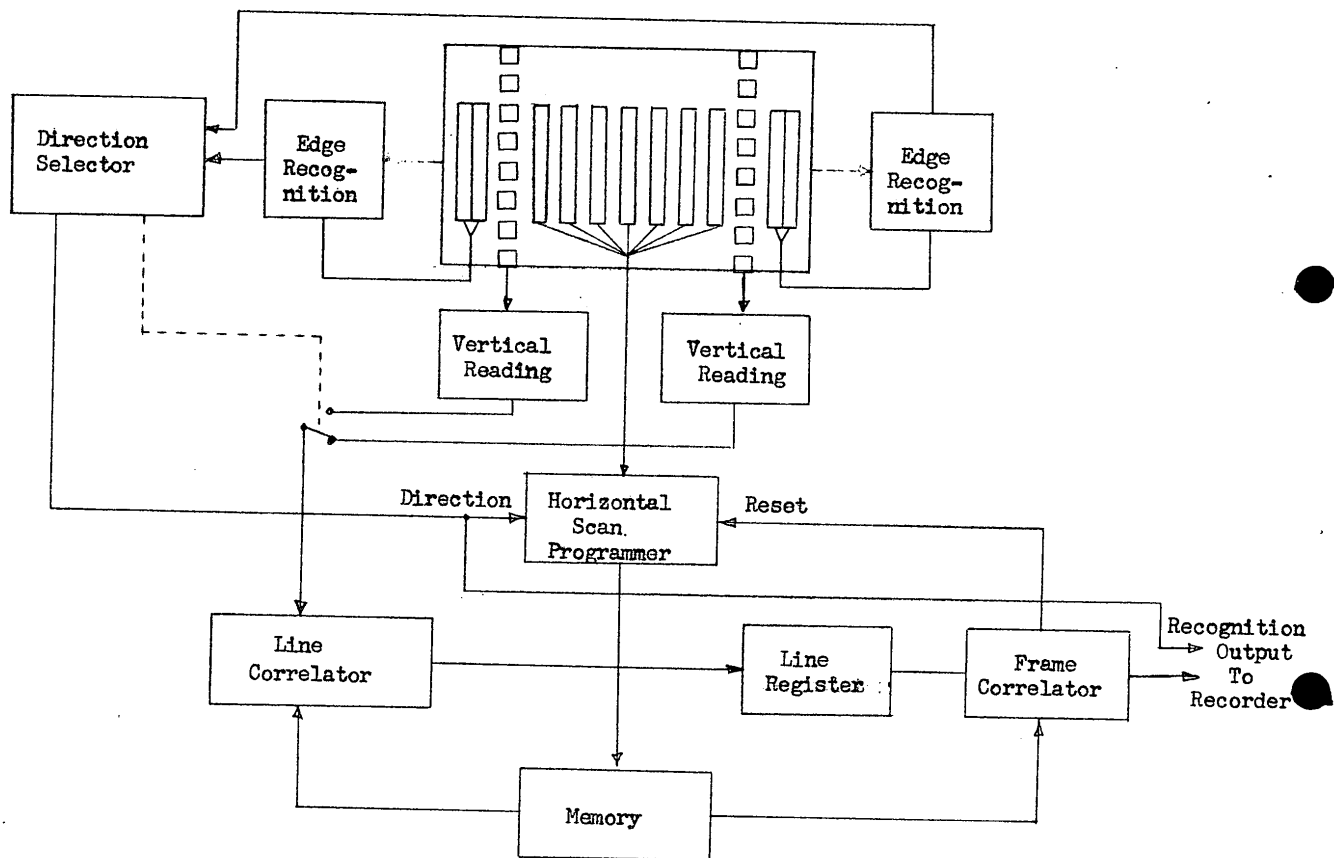


Fig. 2

Scanning arrangement

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Block Diagram

FIG. 3